

Habitability Measurement Research & Development Needs

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Workshop on Opportunities in Space Human Factors Research and Development

Johnson Space Center, Houston, TX

December 11-12, 2002

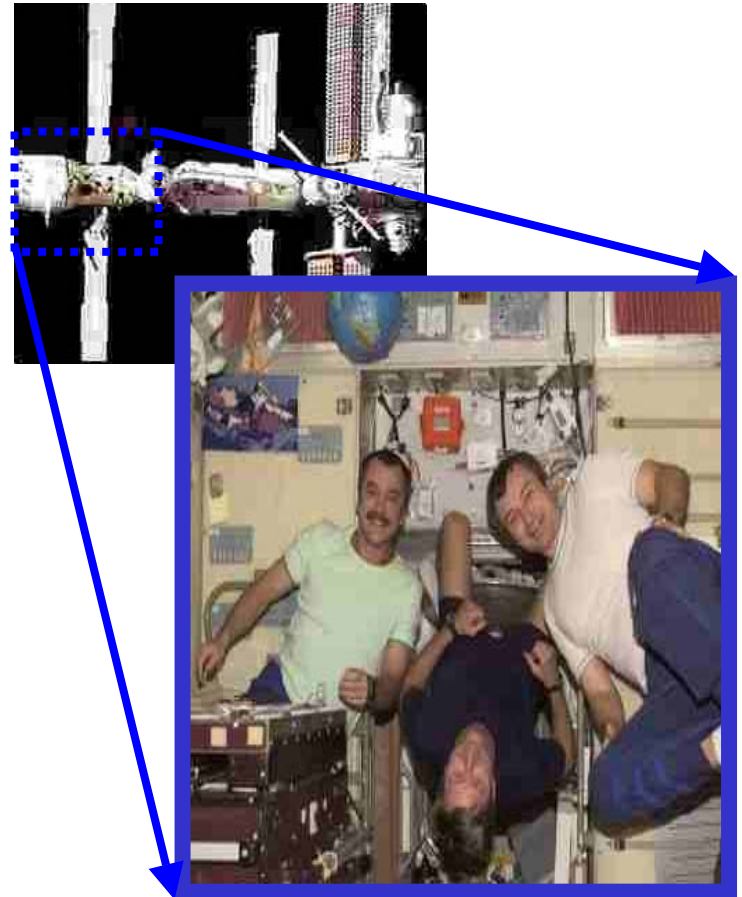
Significance of Habitability

*** *Not merely about Comfort* ***

Habitability operates on human performance & behavior

- Social behavior
- Fatigue & stress
- Cognition
- Efficiency

For a human tended mission, maintaining good habitability is a means of *mission risk mitigation*



Some Habitability Stressors on ISS

Habitability stressors can effect crew fatigue, moral, and interaction.

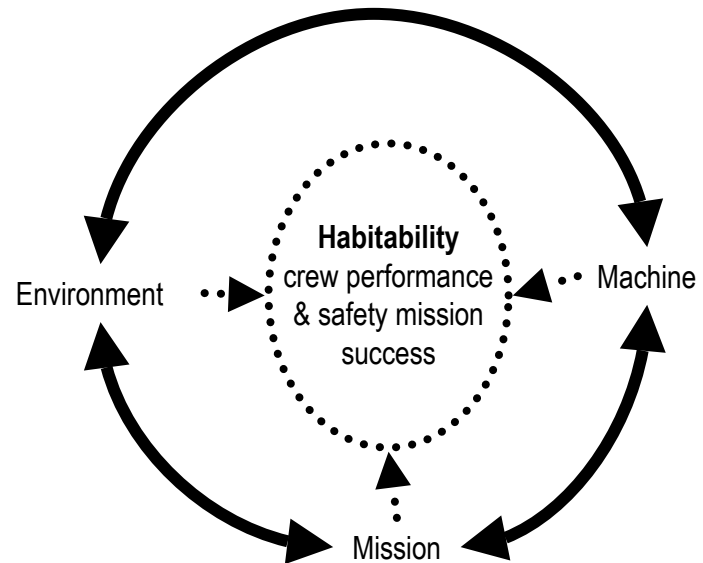
The following issues current characterize ISS habitability

- ✓ In adequate volume for and means of stowage
- ✓ No dedicated and private hygiene facility
- ✓ High levels of constant and intermediate noise
- ✓ Crowded conditions, especially in the living quarters
- ✓ Low area lighting and poor portable lighting
- ✓ No privacy door for crew quarters in the Russian module
- ✓ Limited accessibility to hardware for maintenance

Habitability defined

Quality of environment-machine-mission system that best enables human performance

- **Architecture** - lighting; colors; relative location of activity centers;
- **Habitation activities/hardware**
dining - galley, wardroom, packaging;
sleeping - crew quarters, provisions;
hygiene - compartment, supplies;
exercise - location
- **Crew interfaces** - labels, displays, controls, tools, restraints
- **Operations** (schedule; training; inventory management)



The Habitability Difference

There is consensus on gross relative differences in habitability

Least Habitable



Most Habitable



But not on finer distinctions



?



?



NASA evaluates vehicles & mission prior to flight and makes trade-offs

“Crew have what they need in hardware & environment to perform mission?”

E.g., Muffle noise but decrease available volume

NASA needs a means to compare ultimate outcome of various individual decisions on habitability

➔ *Standard means to describe habitability*

Notable Previous Work Defining Habitability

Frazier (1968), Stuster (1986, 1996)

Lists of aspects or factors of habitability, recommendations for good habitability, intangibles of habitability

Lozar (1978)

Proposed database of correlations between actual building measurements (area, quantity of doors, distance to door) and inhabitants perception of habitability

Celentano, Amorelli, Freeman (1963)

Habitability Index derived from weighted rating of multiple factors

American Bureau of Shipping (2001, 2002)

Actual measurements combined with expert judgments of less quantifiable factors, additive model results in single rating of “fail”, “pass”, or “pass with honors”

What is NASA-JSC doing now?

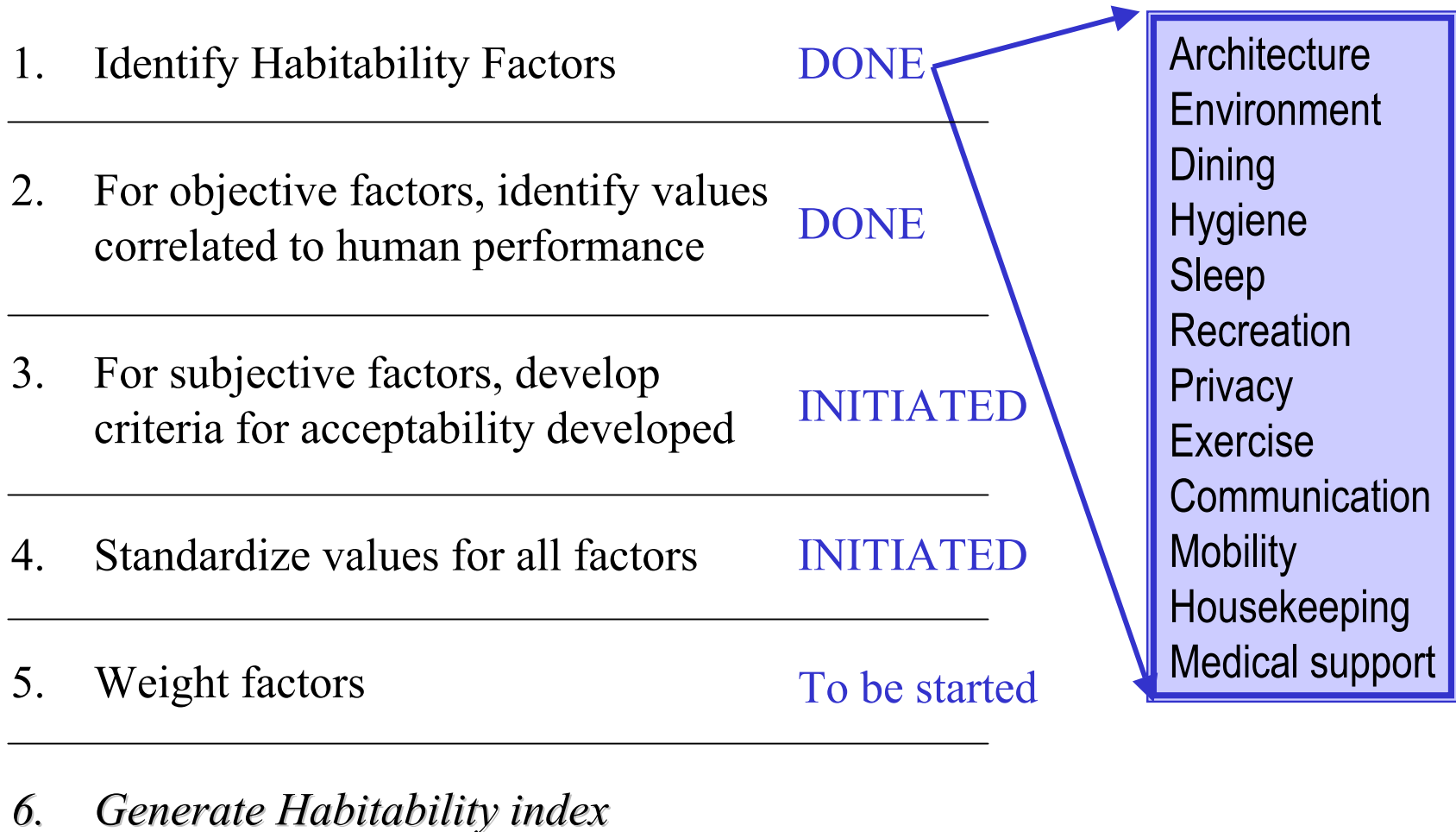
- Human factors requirement verification
Preflight review of documentation, pass fail judgment except in the case of a noncompliance
- Environment measurements
Measurements for air, water, acoustics are acquired to monitor environment
- Debriefs
Post-flight interview with the crew on Habitability and Human Factors issues
- In-flight reporting
In-flight reporting of Human Factors issues
- ➔ **Habitability Index Development**

Habitability Index – The Concept

Example Design Features and *Measurable Characteristics*

- Sleeping quarters (Sleeping)
 - *Size, sound proofing, lighting*
- Rack translation (Moving)
 - *Size, mass, handle size and location, fragility*
- Exercise equipment (Exercising)
 - *Size, restraint adjustability, effort adjustment*
- Robot arm control (Controlling)
 - *Display precision, control sensitivity*
- Labels (Reading)
 - *Font size, code consistency, durability*

Habitability Index Development



Hab Index - Common Format

- In addition to the common currency concept, it is also useful to have a common format for communicating individual and sets of requirements (indices)
- This common format or user interface should facilitate the efficiency with which human factors requirements are communicated.

Heat	<70	70-75	75-80	80-85	85-90	90-95	>95
Light	>50	40-50	30-40	20-30	10-20	5-10	<5
Noise	<40	40-55	55-60	60-65	65-70	70-80	>80
	Acceptable		Uncertain		Unacceptable		

ABHab

An Activity Based Index of Habitability

Name				Date				Place				Context				Reference				Low			
Activity Description General Activities - Concept Demonstration																Importance							
Related / Dependent Activities								Sleeping, Exercising, Working, Moving, Showering, Sightseeing. EVAing, Eating,								Weighting		0		0			
Spatial factors				Height				Width				Length											
Rating				1				1				1				1		1					
Anchor				70				30				70				30							
Environmental factors				Heat				Light				Noise											
Rating				1				1				1				0		0					
Anchor				70				99				50				5				50		90	
Equipment factors				Controls				Displays				Instructions											
Rating				1				1				1				0		1					
Anchor				Good				Bad				Good				Bad				Short		Long	
Communication factors				Availability				Clarity				Access to Experts											
Rating				1				1				1				3		0					
Anchor				24				<1				Good				Bad				24		<1	
Other factors																							
Rating																0		0					
Anchor																							
																Counts		4		2			
																Weights		1.0		2.0			
																Weighted Sum		4		4			
																Importance Weighted		28		28			

Important considerations

1. **Perception of Habitability** → Correlate Inhabitants perception with other measures
2. **Link to Performance** → Enable predictions for mission risk
3. **Qualitative factors** → Need valid means of judging less quantitative factors
4. **Availability of measurements** → Need a tool that can accommodate lack of actual measurements for quantitative factors
5. **Other variables**
 - Time
 - Adaptation
 - Human characteristics
6. **Model vs Index**
7. Can Habitability be described with a single number? Is Habitability a **gestalt**?

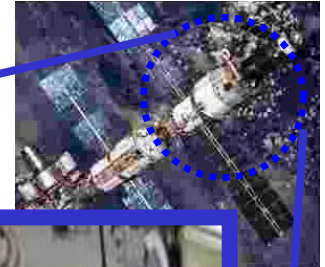
Conclusions

NASA needs a standard means to describe Habitability

- Enable more informed decisions & tradeoffs
- Design better habitats and missions
- Reduce risk
- Increase output of mission

Habitability Index is but one means of addressing this need

Other means of addressing this need are worthy of research and development pursuit



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